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Synthesis of Evidence to Characterize National Measles and Rubella Exposure and Immunization Histories

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Abstract

Population immunity depends on the dynamic levels of immunization coverage that countries achieve over time and any transmission of viruses that occur within the population that induce immunity. In the context of developing a dynamic transmission model for measles and rubella to support analyses of future immunization policy options, we assessed the model inputs required to reproduce past behavior and to provide some confidence about model performance at the national level. We reviewed the data available from the World Health Organization (WHO) and existing measles and rubella literature for evidence of historical reported routine and supplemental immunization activities and reported cases and outbreaks. We constructed model input profiles for 180 WHO member states and three other areas to support disease transmission model development and calibration. The profiles demonstrate the significant variability in immunization strategies used historically by regions and member states and the epidemiological implications of these historical choices. The profiles provide a historical perspective on measles and rubella immunization globally at the national level, and they may help immunization program managers identify existing immunity and/or knowledge gaps.

Keywords

Measles; routine immunization; rubella; supplemental immunization activities (SIAs)

1. INTRODUCTION

Individual immunity derives from infection and/or vaccination, which individuals, physicians, and health systems can track by recording cases of disease and receipt of vaccine. Population immunity represents the aggregation of all individual immunity in the population, and it changes with time.(1) Population immunity drives the dynamics of the transmission of infectious agents (e.g., sustained transmission, disease die-out, or

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episodic transmission following reintroduction), and it determines the burden of disease.[2] Research priorities for global measles and rubella control and eradication identified by a group of experts in 2012 included the need for disease modeling to better understand the levels of population immunity required for elimination in various settings.[3] Using models to characterize population immunity[1] represents a significant opportunity to improve efforts to manage vaccine-preventable diseases prospectively. For example, models can help policymakers evaluate the economic and health tradeoffs of potential management strategies, estimate the impact of immunization and burden of disease,[4–6] and visualize the benefits of interventions that otherwise may not get counted because surveillance systems do not detect prevented cases.[7,8] More importantly, as countries and regions make progress toward (and achieve) elimination goals by increasing population immunity, the number of cases declines significantly and approaches (or reaches) zero.

Modeling population immunity requires integrating data about population demographics, immunization, and exposure history, along with assumptions about the transmissibility of the virus, mixing, and other factors. Prior efforts to assess national-level population immunity led to the development of a simple measles strategic planning (MSP) tool intended for use by national program managers to approximate potential population immunity based on various vaccination strategies.[6] However, the MSP tool did not include a dynamic disease transmission model and a similar tool for rubella does not exist. Developing dynamic transmission models requires that they use time-varying inputs based on the best available evidence, recognizing that significant limitations may exist. Models should rely on transparent and well-founded assumptions and provide estimates consistent with historical programmatic experience, reported cases, and available serological study results.[9]

The Global Vaccine Action Plan[10] established by the World Health Organization (WHO) and its partners and approved by the World Health Assembly in 2012 set a target for measles and rubella elimination in at least five WHO regions by 2020.[10] The Measles and Rubella Initiative developed a strategic plan that indicates the need for additional global, national, and regional commitments to achieve and maintain “high levels of population immunity by providing high vaccination coverage with two doses of measles- and rubella-containing vaccines” through routine immunization (RI) and supplemental immunization activities (SIAs) to stop measles and rubella virus transmission and achieve elimination goals.[11] RI provides doses of vaccine to children as they reach the age(s) indicated by the national immunization schedule, which spreads these doses out throughout the calendar year. In contrast, SIAs involve campaigns that occur over a relatively short period of time and typically target a broad age range. RI and SIAs lead to very different epidemiological consequences, with RI providing steady inflow of immunization and SIAs boosting population immunity in pulses.

To support efforts to make an investment case for global management of measles and rubella,[12] we recognize the need to develop a dynamic model of measles and rubella viral transmission and population immunity. Although we focus on the global or regional scale, data reporting and policy interventions occur at the national level, and getting the global-level estimates correct implies the need to aggregate up from the national level. Application of the model to specific countries requires synthesis of the data used as model

inputs, which led us to construct national model input profiles. The next section describes the methods we used to review the available evidence and to develop the immunization assumptions for the profiles. This work complements a separate review of the literature that characterizes the available serological data.[9]

2. METHODS

We obtained historical immunization data available from the WHO and UNICEF[13–15] and demographic data from the U.N. Population Division (UNPD)[16] to support the characterization of historical and forecasted population dynamics. We excluded from further analysis the following 14 relatively small WHO member states (out of 194 current WHO member states): Andorra, Antigua and Barbuda, Cook Islands, Dominica, Kiribati, The Marshall Islands, Monaco, Nauru, Niue, Palau, Saint Kitts and Nevis, San Marino, Seychelles, and Tuvalu. Our analysis also excludes WHO nonmember states, except that we included three population areas associated with two other large member states: Hong Kong and Macao (China) and Puerto Rico (United States) given the availability of population and immunization data for these areas. The left columns of Table I list the 180 member state profiles and three other geographic areas we characterized by their ISO code and World Bank Income Level[17] organized according to WHO region. The profiles provide data for the states as they existed in 2013, with retrospective population estimates from the UNPD.[16] The profiles account for some major changes that occurred for some states (e.g., creation of new states through independence as well as the dissolution of the Union of Soviet Socialist Republics and Yugoslavia).

For each profile, we reconstructed the immunization history for measles and rubella for both RI and SIAs by year since measles vaccine became available for use in 1963. We used the data available from WHO as a base for reconstruction of national immunization histories, and we relied on papers we identified in our literature review to provide historical and other supplemental information, particularly related to immunization schedules. We started with the RI data available from the WHO-UNICEF estimates, which characterize historical vaccine coverage since 1980.[13–15] We also included data reported by some member states to WHO that extended back to the beginning of the Expanded Programme on Immunization (EPI) in 1974 (Marta Gacic-Dobo, Personal Communication, 2013). For countries established after 1980, UNPD provides retrospective population estimates. For the immunization assumptions, we assume the immunization strategy used by the parent prior member state as reported to WHO from 1974 up until the time of independence and we apportion historical estimates of cases based on the relative population sizes.

Vaccine schedules vary significantly across member states at any single point in time[18,19] and they change for individual member states over time. Consistent with current practice, we assume that vaccine options include continued use of measles- and rubella-containing vaccines (MRCVs) in high-income member states and continued use of measles with or without rubella-containing vaccines (M(R)CVs) in member states of all other income levels.[15,19] Given our focus on measles and rubella only, we characterize the historical vaccine use (i.e., schedule and coverage) according to the measles first dose (MCV1), measles second dose (MCV2), and rubella dose (RCV) given in the primary RI series or

selectively to adolescent and adult females. We report the timing of vaccine introduction for MCV1, MCV2, and RCV (primary and/or selective for adolescent and adult females). Thus, although the WHO rubella vaccine position paper revised in 2011 recommends vaccination of both sexes, because unvaccinated males contribute to sustained rubella virus transmission[20] we sought to capture all historical practices.

To supplement the information available from WHO, we searched the literature indexed in PubMed and the Science Citation Index (ISI Web of Knowledge) up through June 10, 2014 for papers in English to identify additional information about national immunization histories. We searched using the key words “measles” or “rubella” and “(schedule or routine or EPI or supplement*)” and the names of continents, regions, and individual member states. We screened the records for relevance to national or regional immunization practices using indexed information or the full text of articles with insufficient information in the index. For each member state, we capture the RI vaccine used as M, R, or MR to indicate the use of a single antigen or use of both antigens of interest in a combination vaccine and ignoring any additional components (e.g., mumps in MMR).

In 2014, WHO-UNICEF provided estimates of MCV2 coverage for countries that reported MCV2 national coverage estimates for the years 2000–2013. In general, we used the WHO-UNICEF coverage estimates, although in a few instances we modified these based on national data. For example, the WHO-UNICEF MCV1 coverage estimates for the United States for 1980–1993 implied significantly higher coverage nationally than reported in the preceding or following years, and we could not identify the source for the estimates. Based on information from national immunization program experts, who noted the importance of the school immunization requirements and provided unpublished estimates of vaccine procurement data, we used judgment for the values in the profile. We interpolated for missing data and provided estimates for all second doses for those member states that do not report MCV2 coverage to WHO (i.e., the Czech Republic, Finland, Ireland, Italy, and the United States). For historical selective rubella immunization, which primarily occurred in Europe and Australia, we estimated coverage using a single value for the duration based on any national information that we found, although these uncertain values may require adjustment depending on behavior of the transmission model.

We identified some overlap in activities between the RI and SIA data we extracted for some doses, which we reconciled as either delivered through RI or as an SIA. For example, some member states implemented booster doses for children that included delivery in schools (e.g., Cyprus, Japan). If these occurred throughout a school year, we included these in RI, but if they occurred during a shorter period of time then we treated them as SIAs. In the absence of WHO-UNICEF estimates for RCVs, we generally assume the same coverage for measles and rubella for those doses in the RI schedule that include both vaccines. However, for some areas that phased in rubella immunization, we assumed different coverage levels for M and R during the phase-in period (e.g., during the first year or first few years), which leads to separate points (or series) in the RI profile for M and R until the time of complete phase-in. We also characterized the historical SIA activities, starting with a database maintained by the WHO for measles SIAs[21] and then adding information obtained from WHO[18] related to SIAs prior to 2000 and SIAs using rubella-containing

vaccine and using information we found in the literature. For each SIA, we sought to characterize the timing (i.e., start and end date), target population (i.e., age, sex, and/or risk groups), antigens included in the vaccine used (i.e., M, R, or MR, ignoring any other antigens like mumps), estimated coverage, and other characteristics that might impact the interpretation of the data relevant for use in transmission modeling. We classified SIAs as national (n) or subnational (s) to ensure appropriate adjustment of SIA coverage estimates to account for the fraction of the national population targeted by the SIA, similar to the methods used in models to account for subnational polio SIAs.[2]

The information available for comparison to transmission model output comes in two primary forms: reported case series of associated disease and deaths (considering the age distribution when available), which we characterize here, and the results of serological surveys that provide a snapshot of the dynamic population immunity at the point in time of data collection, which we characterize separately.[9] The WHO summarizes reported annual cases for measles and rubella,[15] with data available for some member states back to 1974 for measles and back to 1998 for rubella.[18] We synthesized the reported health outcome data and supplemented them with data from the literature that summarized reported cases for earlier dates when available, and we particularly searched for information about the timing of large outbreaks that occurred prior to case reporting to WHO for the two different diseases.[15] Surveillance systems typically miss cases, and consequently reported cases most likely underestimate actual cases. Relatively recent modeling efforts provided retrospective estimates for measles,[5] which we considered for purposes of comparison.

3. RESULTS

Table I summarizes the evidence that we identified for the different member states organized by region. Since not all member states currently include rubella immunization in their existing national immunization schedules,[19] we include our current assumptions (noted with an a) about when member states yet to introduce rubella vaccine might do so in response to the current Gavi funding opportunity and/or regional goals to control or eliminate rubella.[22] For the full profile, we characterize the RI schedule, antigens included in the vaccine (i.e., M, R, or MR), and estimated coverage by year historically for each member state. Table I summarizes the evidence base we used as a basis for our assessments.

Table II summarizes the historical SIAs as national (n) or subnational (s) according to the year in which the SIAs started for the data we identified. Blank lines in Table II generally indicate no SIAs performed, particularly for high-income countries, but the data remain limited, probably miss many (most) SIAs conducted for outbreak response, and may include planned SIAs that did not actually occur or exclude SIAs that occurred but we did not find recorded. For areas with more than one SIA during a year (i.e., multiple subnational SIAs), we indicated the total number of separate SIAs. In some cases, we found information in the literature that indicated an SIA strategy instead of RI for the delivery of child immunization during the early part of the immunization program (e.g., Albania, Romania). In such cases, we used the WHO-UNICEF estimated coverage for SIAs during the affected years and we began RI once this approach ended. This change led to later implied dates of RI starting for

MCV1 in Table I for some member states than implied by assuming that the WHO-UNICEF coverage estimates all reflect delivery in RI.

Figs. 1–8 show the full profiles for the United States, the Netherlands, Japan, Oman, Vietnam, Kenya, Ethiopia, and Haiti, respectively, as examples. Part (a) in each profile shows the historical RI coverage estimates by year and schedule. The RI schedule includes the age and the antigens in the vaccine (i.e., M for measles vaccine, R for rubella vaccine, and MR for any combination vaccine including both antigens). We use colors (visible in the on-line version) to show different vaccines and/or schedules. If introduction of the vaccine occurred after January in a year, then we estimated the coverage for the full year adjusting for the fraction of the year with introduction. Thus, when the country switched from a MCV to a MRCV after January of a year, we showed the M and R coverage for the year separately, which makes the R value appear as a single point (e.g., Fig. 2a or 4a). The SIAs for each country appear in Table II. Parts (b) and (c) of the profile show the reported measles and rubella cases, respectively, and prior model estimates (if available) for comparison for relevant time periods.[5] We provide access to the full profiles for all of the 183 modeled areas on the Kid Risk website.[23]

The profiles show a wide range of immunization schedules and coverage that evolved over time, and highly variable epidemiological experience with measles and rubella cases. Comparing the figures for coverage levels and incidence overall suggests that increased immunization coverage significantly decreases incidence. However, as coverage increases to high levels, as occurred in the United States, the Netherlands, Japan, and Oman, the incidence data do not show complete disappearance of cases due to importations. In the United States, heterogeneity in immunization coverage continues to lead to outbreaks following the importation of measles,[24,25] although these cases appear barely visible in Fig. 1b compared to historical incidence. In the United States, aggressive outbreak response efforts control outbreaks relatively quickly. Starting the *x*-axis scale in 1998 in Fig. 1c for rubella for the United States misses the impact of heterogeneity and the outbreaks of rubella that occurred in the Amish in the early 1990s,[26] but uses a *y*-axis scale large enough that the relatively small number of annual importation-related cases appear barely visible. Fig. 4c for the much smaller total population in Oman shows the relatively small number of cases primarily from importations it reports annually. In contrast, Figs. 2b and 2c show episodic outbreaks in the Netherlands, which reflect the significant impacts of clustering of its under-vaccinated religious subpopulation. In Japan, rubella immunization initially targeted adolescent girls only, which did not eliminate rubella transmission in the general population. Difficulties due to the mumps antigen following the introduction of MMR around 1990 in Japan led to heterogeneity in coverage of M and R in RI, and the buildup of susceptible individuals, who supported outbreaks in the early 2000s and 2010s. Figs. 5b and 5c for Haiti show the impact of the aggressive efforts by the WHO Region of the Americas (i.e., PAHO) to use wide age range SIAs to eliminate measles and rubella, which in contrast to> Fig 6b shows the decreasing measles incidence with improved coverage and late introduction of MCV2 into RI in Vietnam. Figs 6c, 7c, and 8c show reported incidence of rubella, although this probably reflects underreporting given the absence of RCV use.

4. DISCUSSION

Our efforts to synthesize the available immunization and epidemiological data for measles and rubella at the national level provide a foundation for modeling measles and rubella transmission globally. Significant variability in the profiles suggests the need to model transmission of measles and rubella at the national level for larger-scale analyses and then aggregate the results to the regional or global level. We expect that our analysis should facilitate such modeling. The syntheses reveal potential immunity gaps, with low vaccination coverage in some years translating into relatively large proportions of accumulating susceptible individuals in the absence of SIAs to catch up unimmunized individuals. In some cases, outbreaks probably led to immunity in some fraction of the unimmunized individuals. Immunization program managers must manage population immunity to stop transmission, and these profiles may serve as a reminder about potentially accumulating susceptible individuals due to relatively low coverage in the past. Social disruptions (e.g., natural disasters, conflict) negatively impact national immunization programs, and catching up individuals missed due to such disruptions should represent a priority for national efforts to close immunity gaps.

The comparisons between the reported cases and cases estimated by prior models demonstrate the absence of prior model estimates for some countries. We identified historical reported cases before 1974 for only a relatively small number of high-income member states (e.g., the United States, the United Kingdom). We encountered the most difficulty finding information about rubella cases, particularly in Africa, and we suspect that member states most likely reported some of the historical rubella cases as measles cases due to the similarity of the clinical presentation. Increased use and expansion of laboratory methods that characterize both viruses promise to provide better information in the future.

Despite our extensive efforts, several data gaps remain. We could not find complete information for most of the 183 areas. We found conflicting information for some areas, and we did our best to resolve this using the available literature. Our efforts to reconstruct historical experiences did not benefit from review by national experts. In addition to concerns and limitations associated with underreported incidence, incorrect reporting of coverage also represents a concern. Underreporting of coverage, perhaps due to vaccine delivered in the private sector, may suggest immunity gaps that do not exist. A much larger concern, however, comes from overreporting of coverage, which may provide a false sense of security about the absence of immunity gaps. The use of the data in this synthesis comes with many limitations due to unknown and potentially poor data quality. We hope that this effort will motivate national experts to provide corrections to our assumptions such that modeling efforts can benefit from the best available information.

This synthesis of the available data should provide a useful starting point for measles and rubella transmission models and help to make assumptions about immunization inputs more transparent.

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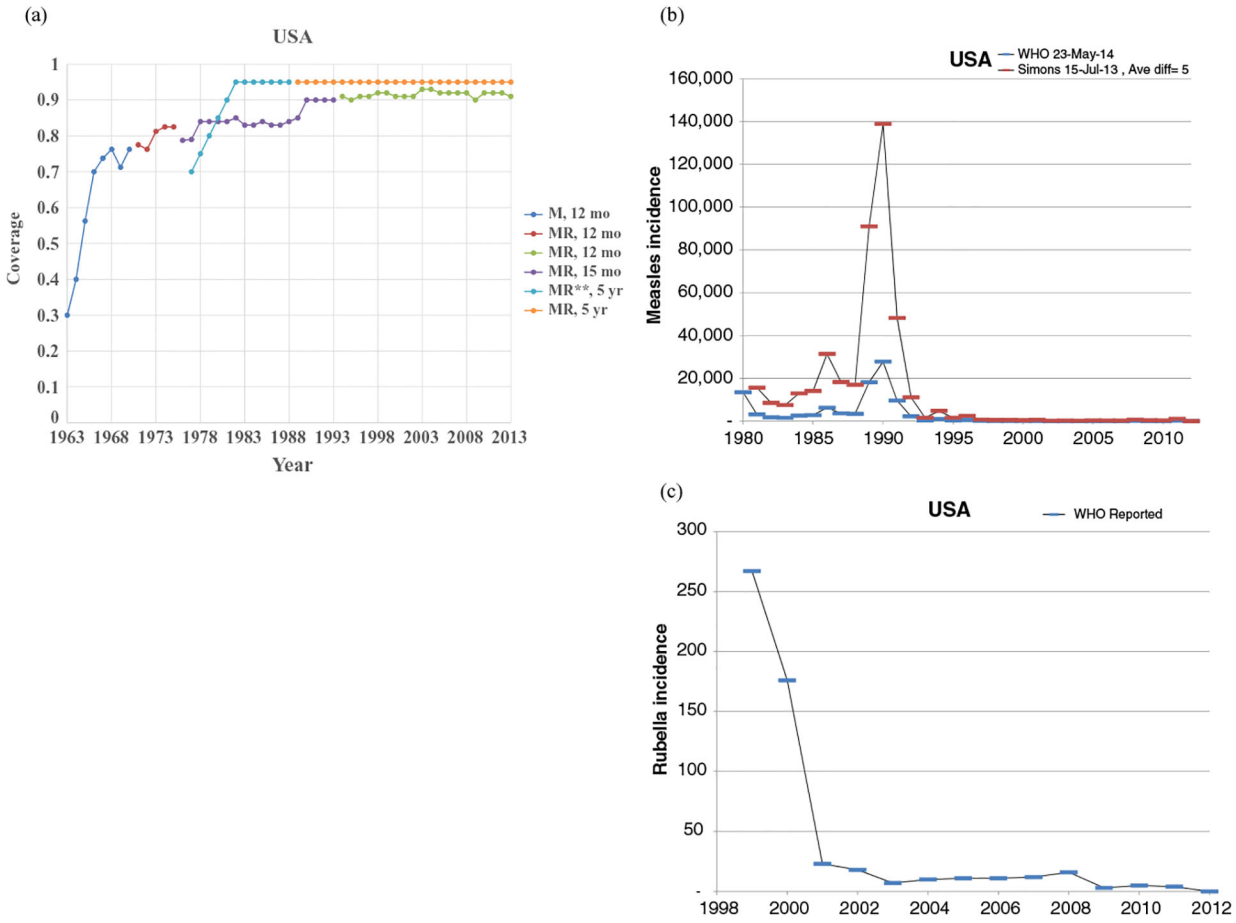

Fig. 1.
Profile for the United States.

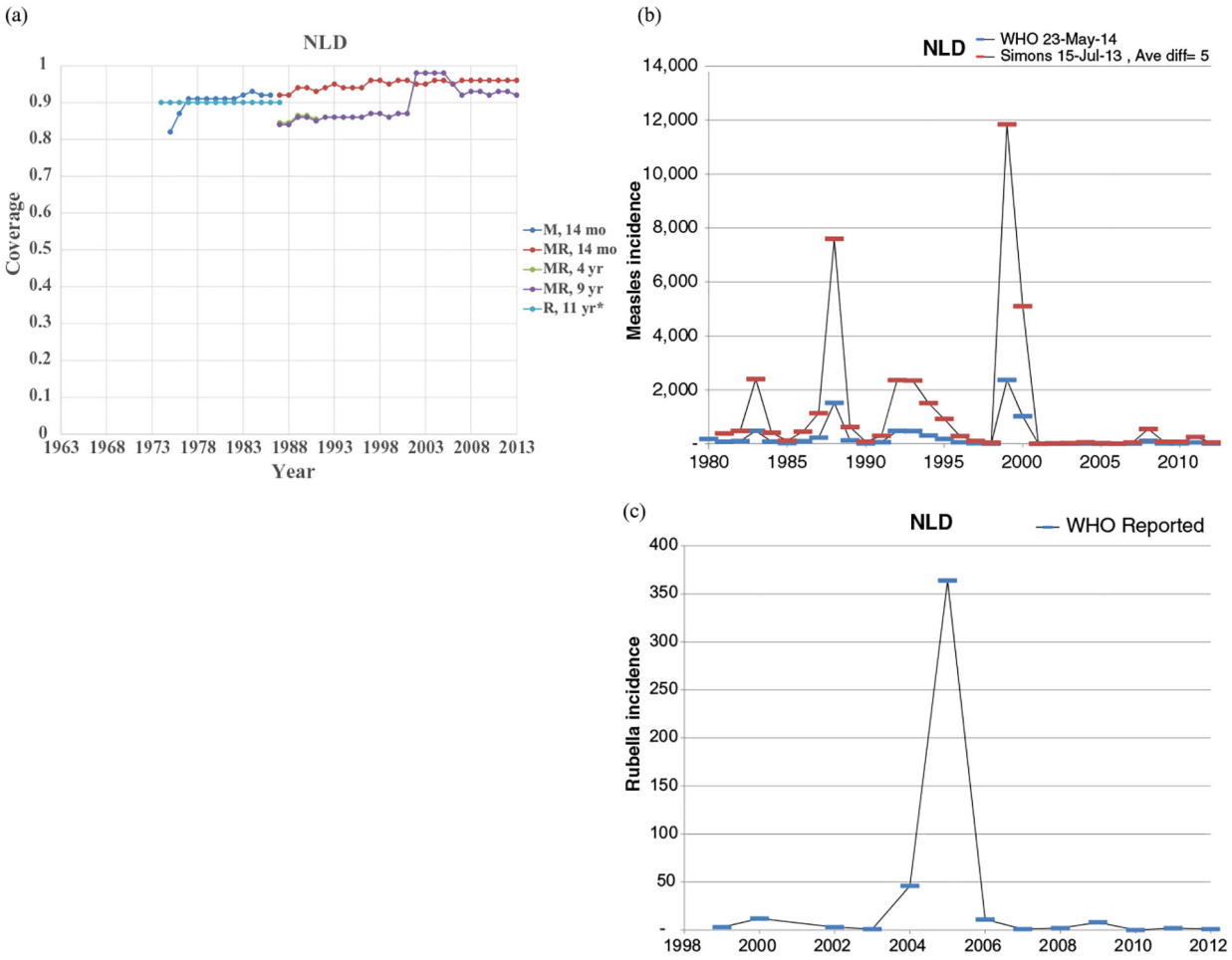

Fig. 2.
Profile for the Netherlands.

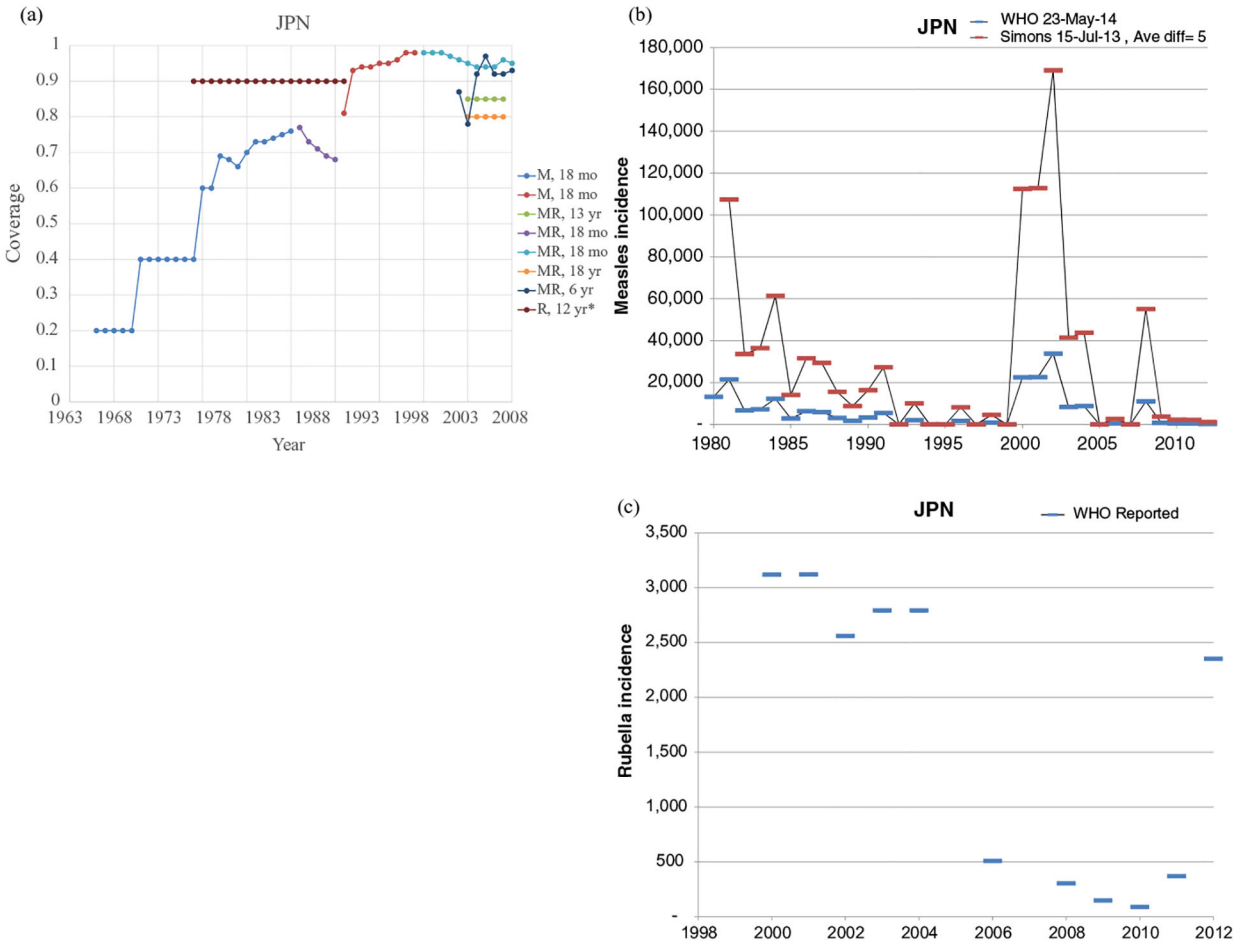

Fig. 3.
Profile for Japan.

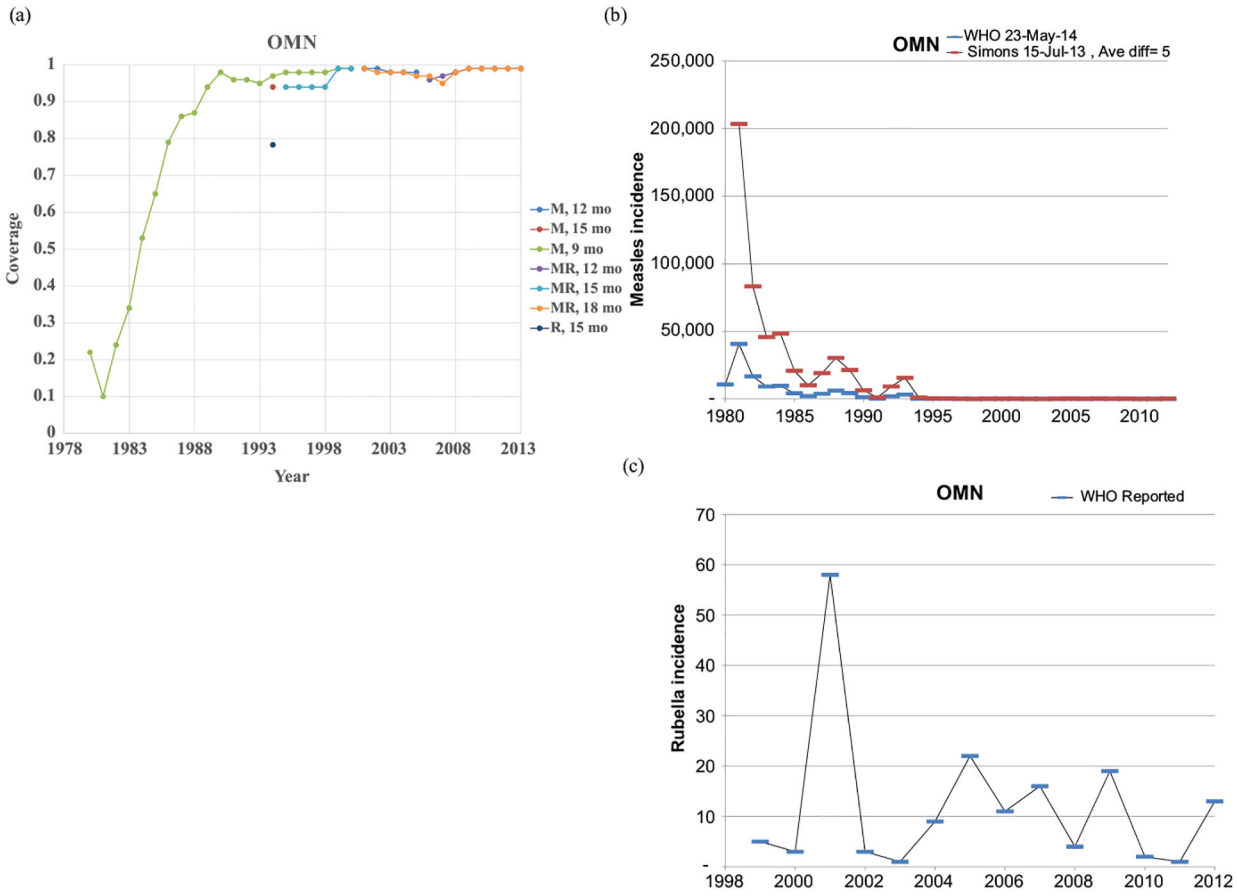

Fig. 4.
Profile for Oman.

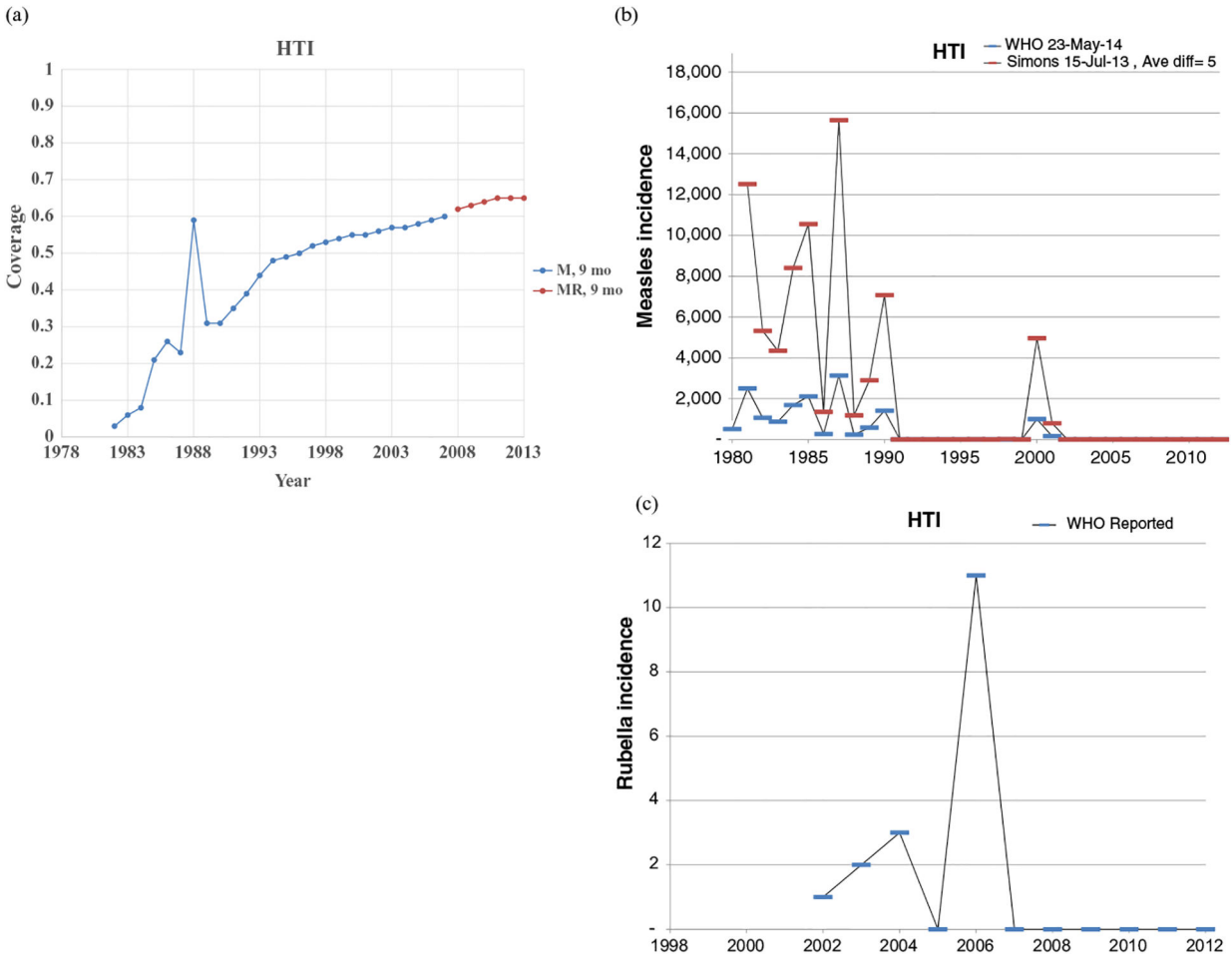

Fig. 5.
Profile for Haiti.

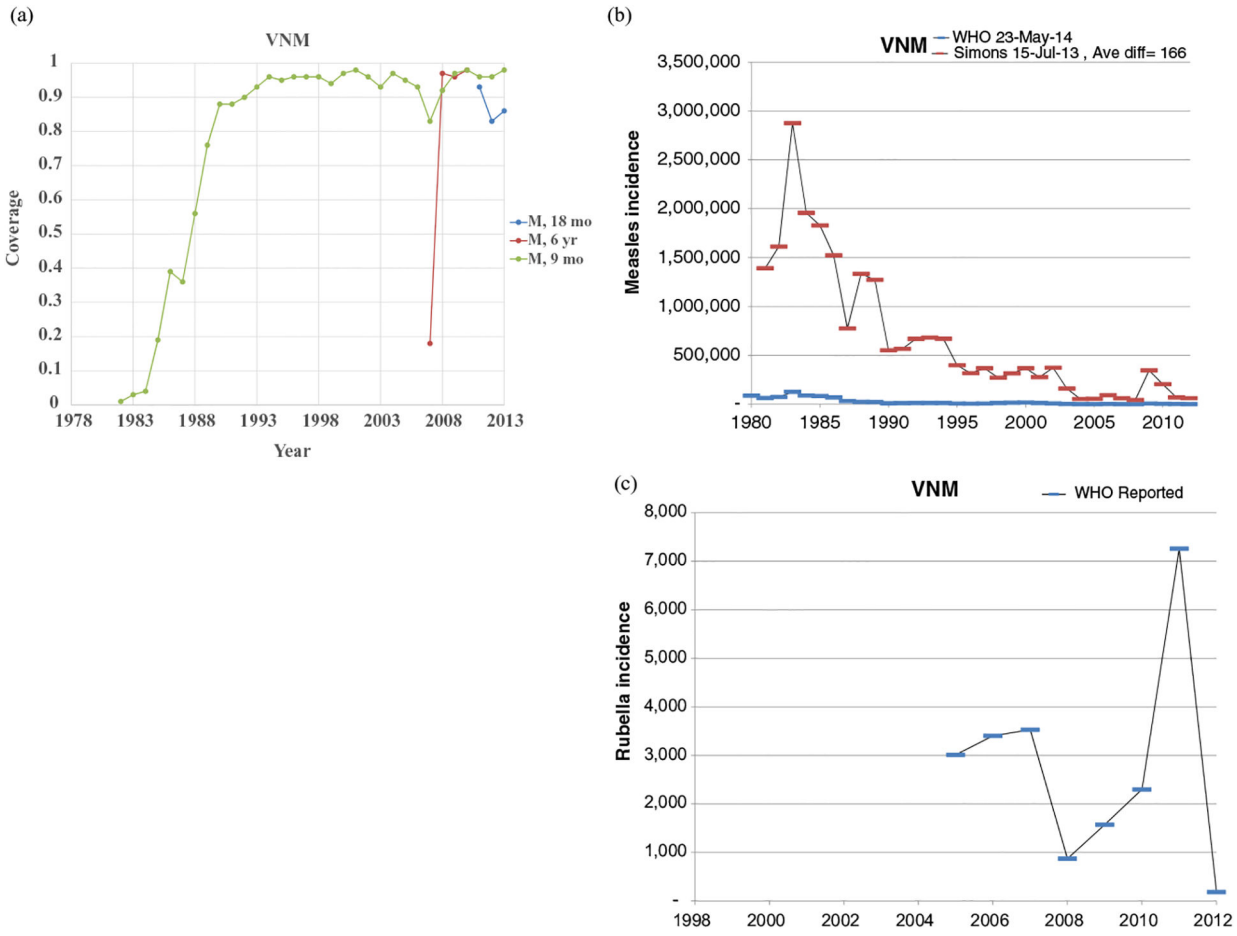

Fig. 6.
Profile for Vietnam.

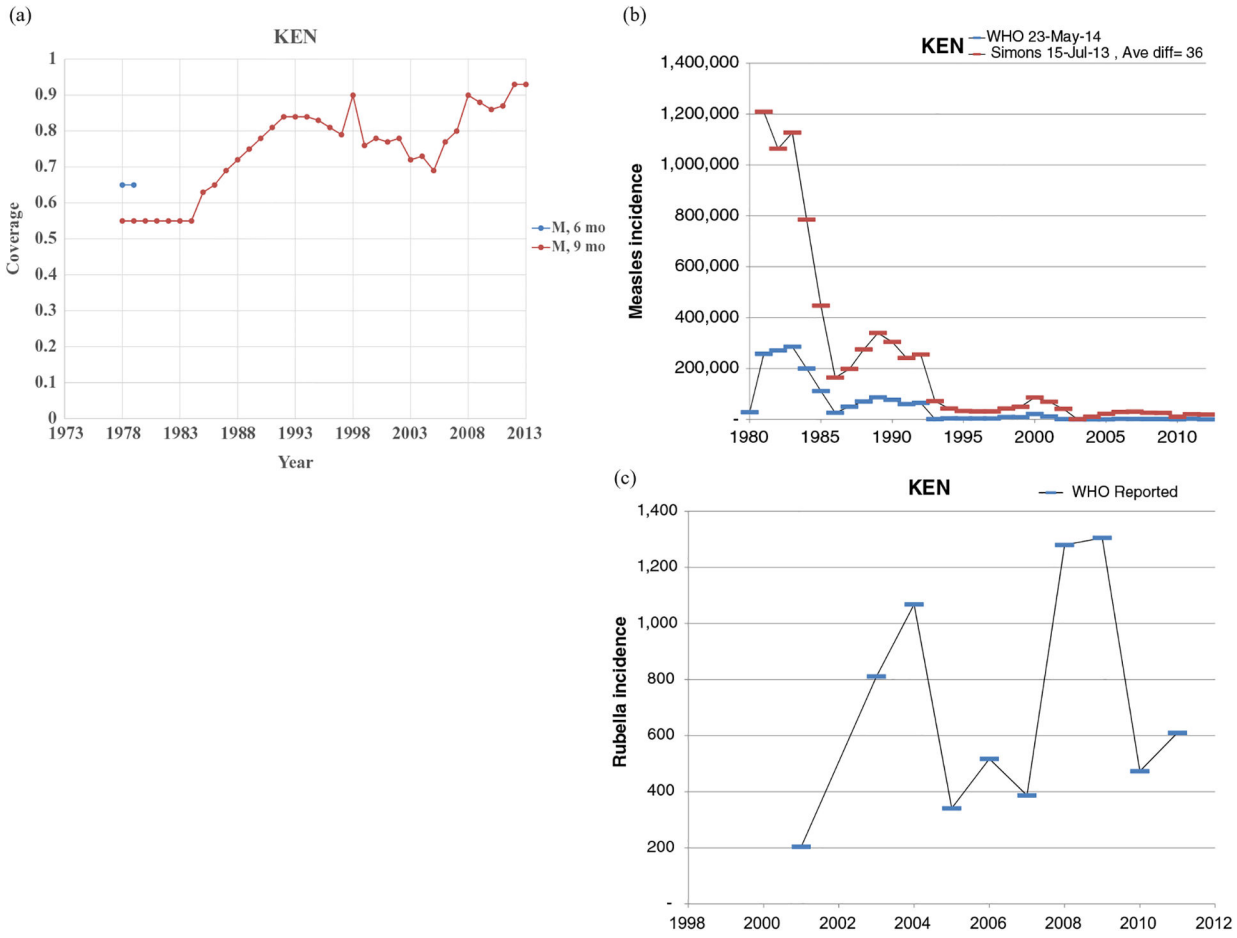

Fig. 7.
Profile for Kenya.

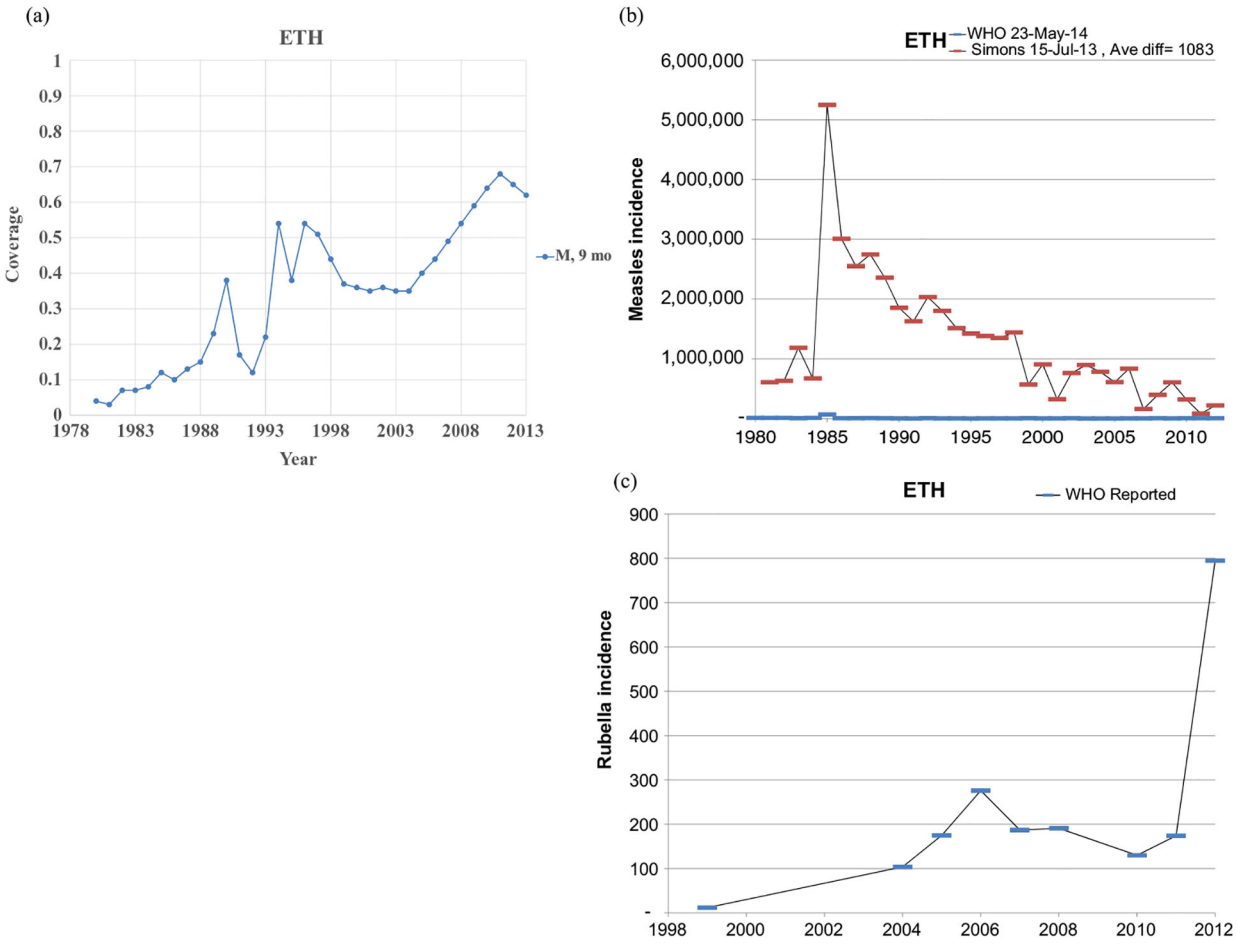

Fig. 8.
Profile for Ethiopia.

Table I.

Characteristics of Modeled Areas in 2013, Including World Bank Income Level (WBIL),[17] Population,[16] Year of Routine Immunization (RI) Introduction of a Measles-Containing Vaccine First Dose (MCV1), Second Dose (MCV2), and Rubella-Containing Vaccine (RCV) in the Primary Series and/or Given Selectively to Female Adolescents; We Include Potential Future Introductions (Note a) and List the References Used to Characterize RI

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
Africa (AFR)								28–33
Algeria	DZA	UMI	39.2	1985	1997	2015[a]		
Angola	AGO	UMI	21.5	1983		2017[a]		
Benin	BEN	LOW	10.3	1979		2017[a]		34
Botswana	BWA	UMI	2.0	1976	2011	2016[a]		35
Burkina Faso	BFA	LOW	16.9	1980	2015[a]	2015[a]		36–38
Burundi	BDI	LOW	10.2	1981	2013	2016[a]		39
Cameroon	CMR	LMI	22.3	1966		2015[a]		40–45
Cape Verde	CPV	LMI	0.5	1985	2010	2010		46
Central African Republic	CAF	LOW	4.6	1967		2017[a]		47,48
Chad	TCD	LOW	12.8	1967		2018[a]		49–53
Comoros	COM	LOW	0.7	1984	2016[a]	2016[a]		
Congo, Democratic Republic	COD	LOW	67.5	1967		2017[a]		54–57
Congo, Republic	COG	LMI	4.4	1967		2016[a]		
Cote d'Ivoire	CIV	LMI	20.3	1984		2017[a]		58
Equatorial Guinea	GNQ	UMI[b]	0.8	1985		2018[a]		
Eritrea	ERI	LOW	6.3	1980	2012	2018[a]		
Ethiopia	ETH	LOW	94.1	1980	2016[a]	2017[a]		59–64
Gabon	GAB	UMI	1.7	1985		2019[a]		
Gambia, The	GMB	LOW	1.8	1967	2012	2015[a]		65–71
Ghana	GHA	LMI	26.0	1978	2012	2013		72–74
Guinea	GIN	LOW	11.7	1974		2018[a]		
Guinea-Bissau	GNB	LOW	1.7	1983		2018[a]		75–77

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
Kenya	KEN	LOW	44.4	1978	2013	2015[a]		78–85
Lesotho	LSO	LMI	2.1	1981	1992	2016[a]		
Liberia	LBR	LOW	4.3	1974		2017[a]		86
Madagascar	MDG	LOW	22.9	1984	2015[a]	2016[a]		87
Malawi	MWI	LOW	16.4	1980	2015[a]	2016[a]		35,88,89
Mali	MLI	LOW	15.3	1974		2017[a]		90
Mauritania	MRT	LMI	3.9	1974		2017[a]		91
Mauritius	MUS	UMI	1.2	1982	2003	2019[a]		
Mozambique	MOZ	LOW	25.8	1981	2015[a]	2017[a]		88,92–99
Namibia	NAM	UMI	2.3	1975	2015[a]	2015[a]		100
Niger	NER	LOW	17.8	1974		2018[a]		101,102
Nigeria	NGA	LMI	173.6	1974		2017[a]		103–110
Rwanda	RWA	LOW	11.8	1981	2014[a]	2014		111
Sao Tome and Principe	STP	LMI	0.2	1981	2013	2017[a]		
Senegal	SEN	LMI	14.1	1986	2014[a]	2013		112
Sierra Leone	SLE	LOW	6.1	1974	2015[a]	2016[a]		113
South Africa	ZAF	UMI	52.8	1975	1994	2019[a]		100,114
South Sudan	SSD	LOW	11.3	1981		2017[a]		
Swaziland	SWZ	LMI	1.2	1981	1995	2014		
Togo	TGO	LOW	6.8	1967		2016[a]		
Uganda	UGA	LOW	37.8	1981		2018[a]		
United Republic of Tanzania	TZA	LOW	49.3	1970		2014		115
Zambia	ZMB	LMI	14.5	1983		2016[a]		
Zimbabwe	ZWE	LOW	14.1	1981		2015		
Americas (AMR)								116–119
Argentina	ARG	UMI	41.4	1978	1998	1997		120,121
Bahamas, The	BHS	HIGH	0.4	1978	2001	1991		
Barbados	BRB	HIGH	0.3	1977	1997	1977		122

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
Belize	BLZ	UMI	0.3	1980	2005	1996		
Bolivia	BOL	LMI	10.7	1979	(2011)[c]	2000		123
Brazil	BRA	UMI	200.4	1973	1992	1992[d]		124–126
Canada	CAN	HIGH	35.2	1963	1997	1969	1971–1982	127
Chile	CHL	HIGH	17.6	1964	1992	1990		128–130
Colombia	COL	UMI	48.3	1979	1997	1995		131
Costa Rica	CRI	UMI	4.9	1967	1992	1974		132–134
Cuba	CUB	UMI	11.3	1971	2004	1988		135,136
Dominican Republic	DOM	UMI	10.4	1974	(2004)[c] 2009	2004		137
Ecuador	ECU	UMI	15.7	1979	2008	1997		138
El Salvador	SLV	LMI	6.3	1979	2000	1997		138
Grenada	GRD	UMI	0.1	1982	2000	1993		
Guatemala	GTM	LMI	15.5	1980[a]		2001		139
Guyana	GUY	LMI	0.8	1982	2001	1995		
Haiti	HTI	LOW	10.3	1982		2008		140–142
Honduras	HND	LMI	8.1	1979		1997		143
Jamaica	JAM	UMI	2.8	1978	2002	1993	1978–2001	144,145
Mexico	MEX	UMI	122.3	1973	1991	1998		146,147
Nicaragua	NIC	LMI	6.1	1979		1998		
Panama	PAN	UMI	3.9	1979	1992	1992		148,149
Paraguay	PRY	LMI	6.8	1980	(2002)[c] 2004	2000		147
Peru	PER	UMI	30.4	1979	2007	2003		
St. Lucia	LCA	UMI	0.2	1982	1991	1986		150
St. Vincent and the Grenadines	VCT	UMI	0.1	1982	1997	1991		
Suriname	SUR	UMI	0.5	1979	2005	1993		
Trinidad and Tobago	TTO	HIGH	1.3	1984	2001	1984	1982–2000	151,152
United States	USA	HIGH	320.1	1963	1989	1969		153–158
Puerto Rico[e]	PRI	HIGH	3.7	1963	1989	1969		
Uruguay	URY	HIGH	3.4	1979	1992	1982		
Venezuela, RB	VEN	UMI	30.4	1980	2009	1998		131,159,160

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
Eastern Mediterranean (EMR)								161–163
Afghanistan	AFG	LOW	30.6	1978	2004	2018[a]		164
Bahrain	BHR	HIGH	1.3	1974	1985	1985		165,166
Djibouti	DJI	LMI	0.9	1982	2011	2019[a]		
Egypt, Arab Rep.	EGY	LMI	82.1	1977	1999	1999		167,168
Iran, Islamic Rep.	IRN	UMI	77.4	1967	1984	2004		169,170
Iraq	IRQ	UMI	33.8	1980	1989	1989	1995–2004	171
Jordan	JOR	UMI	7.3	1979	1995	2000		172
Kuwait	KWT	HIGH	3.4	1980	1985	1985	1975–2013	173
Lebanon	LBN	UMI	4.8	1982	1995	1995		
Libya	LBY	UMI	6.2	1980	2001	2001		
Morocco	MAR	LMI	33.0	1982	2003	1986[d]		174
Oman	OMN	HIGH	3.6	1980	1994	1994	1996–2013	175–177
Pakistan	PAK	LMI	182.1	1980	2009	2016[a]		
Qatar	QAT	HIGH	2.2	1980	1996	1992		
Saudi Arabia	SAU	HIGH	28.8	1974	1991	1991	1978–1991	178
Somalia	SOM	LOW	10.5	1979		2016[a]		179
Sudan	SDN	LMI	38.0	1981	2012	2015[a]		
Syrian Arab Republic	SYR	LMI	21.9	1980	1993	1999		
Tunisia	TUN	UMI	11.0	1979	1981	2004		180,181
United Arab Emirates	ARE	HIGH	9.3	1980	1984	1984	1998–2013	182
Yemen, Rep.	YEM	LMI	24.4	1980	2004	2014		
Europe (EUR)								183–188
Albania	ALB	UMI	3.2	1990[f]	2001	2001		189
Armenia	ARM	LMI	3.0	1967	1986	2002		190
Austria	AUT	HIGH	8.5	1974	1994	1994	1984–1994	191–193
Azerbaijan	AZE	UMI	9.4	1967	2001	2003		190
Belarus	BLR	UMI	9.4	1967	1987	1996		190,194
Belgium	BEL	HIGH	11.1	1975	1994	1985	1973–1994	195
Bosnia and Herzegovina	BIH	UMI	3.8	1969	1975	1975[d]	1977–2008	196,197

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
Bulgaria	BGR	UMI	7.2	1969	1982	1993	1988–2000	198
Croatia	HRV	HIGH	4.3	1968[g]		1975	1975–2003	199,200
Cyprus	CYP	HIGH	1.1	1974	(2004)[c] 2006	1989	1974–1989	
Czech Republic	CZE	HIGH	10.7	1969	1975	1986	1982–1997	201
Denmark	DNK	HIGH	5.6	1987[g]		1987		202
Estonia	EST	HIGH	1.3	1967	1986	1992		190
Finland	FIN	HIGH	5.4	1975	1982	1982	1975–1988	203–205
France	FRA	HIGH	64.3	1983	1996	1983	1970–1996	206–208
Georgia	GEO	LMI	4.3	1966	(1988, 1989, 1993)[c] 1997	2004		209
Germany	DEU	HIGH	82.7	1970	1986	1980	1975–1997	210–212
Greece	GRC	HIGH	11.1	1975	1991	1989	1977–1989	213,214
Hungary	HUN	UMI	10.0	1974	1989	1989		215,216
Iceland	ISL	HIGH	0.3	1976	2003	1989	1977–2002	217
Ireland	IRL	HIGH	4.6	1983	1992	1988	1971–1988	218,219
Israel	ISR	HIGH	7.7	1967	1994	1988	1973–1979	220,221
Italy	ITA	HIGH	61.0	1976	2004	1990	1972–2008	222,223
Kazakhstan	KAZ	UMI	16.4	1967	1986	2005		190,224
Kyrgyz Republic	KGZ	LOW	5.5	1967	1986	2002		190,225,226
Latvia	LVA	HIGH	2.1	1967	1986	1993	1993–2002	190
Lithuania	LTU	HIGH	3.0	1967	1986	1992	1992–1996	190,227
Luxembourg	LUX	HIGH	0.5	1983	1994	1994		228
Macedonia, FYR	MKD	UMI	2.1	1969	1997	1983	1975–2012	196,229
Malta	MLT	HIGH	0.4	1983	1991	1989[d]	1976–1992	230
Moldova	MDA	LMI	3.5	1967	1986	2002		190
Montenegro	MNE	UMI	0.6	1972	1995	1995	1977–1992	196,197,231
Norway	NOR	HIGH	5.0	1969	1983[g]	1983	1978–1982	232
Poland	POL	HIGH	38.2	1974	1991	1988	1989–2005	233
Portugal	PRT	HIGH	10.6	1980	1990	1984	1984–1990	234,235
Romania	ROU	UMI	21.7	1998[a]	1998	2002		236,237

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
Russian Federation	RUS	HIGH	142.8	1967	1986	2000		190
Serbia	SRB	UMI	9.5	1971	1993	1993		238
Slovak Republic	SVK	HIGH	5.5	1980	1975	1986	1985–1992	201
Slovenia	SVN	HIGH	2.1	1968	1978	1990	1973–1990	239
Spain	ESP	HIGH	47.0	1978	1996	1981	1979–1994	240,241
Sweden	SWE	HIGH	9.6	1971	1982[g]	1982	1972–1982	242
Switzerland	CHE	HIGH	8.1	1971	1996	1971	1974–1986	243–245
Tajikistan	TJK	LOW	8.2	1967	1986	2009		190
The Netherlands	NLD	HIGH	16.8	1976	1987	1987	1974–1987	246–248
Turkey	TUR	UMI	74.9	1987	1997	2006		249–251
Turkmenistan	TKM	UMI	5.2	1967	1988	2007		190
Ukraine	UKR	LMI	45.2	1967	1986	2001		190,252
United Kingdom	GBR	HIGH	63.1	1968	1996	1988	1970–1988	253–256
Uzbekistan	UZB	LMI	28.9	1967	1986	2006		190
Southeast Asia (SEAR)								257,258
Bangladesh	BGD	LOW	156.6	1980	2012	2012		259
Bhutan	BTN	LMI	0.8	1979	2006	2006		260
India	IND	LMI	1252.1	1985	2010	2015[a]		261,262
Indonesia	IDN	LMI	249.9	1983	2003	2018[a]		263
Korea, Dem. Rep.	PRK	LOW	24.9	1980	2008	2015[a]		
Maldives	MDV	UMI	0.3	1981	2007	2007		
Myanmar	MMR	LOW	53.3	1986	2008	2015[a]		264
Nepal	NPL	LOW	27.8	1981	2014[a]	2014		
Sri Lanka	LKA	LMI	21.3	1984	2001	1996	1996–2010	265
Thailand	THA	UMI	67.0	1984	1996	1996	1986–1998	266–269
Timor-Leste	TLS	LMI	1.1	1983		2015[a]		
Western Pacific (WPR)								270,271
Australia	AUS	HIGH	23.3	1975	1994	1993	1971–1993	272,273
Brunei Darussalam	BRN	HIGH	0.4	1970	1997	1984		
Cambodia	KHM	LOW	15.1	1984	2012	2013		

Region and Member State	ISO	WBIL	Population (Millions)	MCV1	MCV2	RCV Primary	RCV Female Adolescents	References[13–15,27]
China	CHN	UMI	1385.6	1965	1965	2008		274–276
Hong Kong SAR, China[e]	HKG	HIGH	7.2	1983	2001	1990		277–279
Macao SAR, China[e]	MAC	HIGH	0.6	1983	2001	1985		
Fiji	FJI	UMI	0.9	1980	2003	2003	1975–1994	280,281
Japan	JPN	HIGH	127.1	1966	2008	1989[h]	1977–1994	282–284
Korea, Rep.	KOR	HIGH	49.3	1965	1997	1980		285,286
Lao PDR	LAO	LMI	6.8	1981	2012	2013		287,288
Malaysia	MYS	UMI	29.7	1983	2002	2002	1987–2008	289–293
Micronesia, Fed. Sts.	FSM	LMI	0.1	1987	1995	1970[d]		294
Mongolia	MNG	LMI	2.8	1967	1987	2009		
New Zealand	NZL	HIGH	4.5	1969	1992	1970	1979–1991	295,296
Papua New Guinea	PNG	LMI	7.3	1983	1991[i]	2015[a]		297–299
Philippines	PHL	LMI	98.4	1982	2009	2009		
Samoa	WSM	LMI	0.2	1982	(2002)[c] 2006	2004		
Singapore	SGP	HIGH	5.4	1976	1990	1990	1976–1981[a]	300,301
Solomon Islands	SLB	LMI	0.6	1986	2012	2012		
Tonga	TON	UMI	0.1	1981	2002	2002		
Vanuatu	VUT	LMI	0.3	1982		2014		
Vietnam	VNM	LMI	91.7	1982	2006	2015[a]		

[a] Assumption about future vaccine adoption.

[b] High-income country grouped with UMI countries given vaccine use.

[c] Schedule included second dose in year(s) in parentheses prior to the start of the continuous two-dose schedule that started in the year not in parentheses (if MCV2 introduced).

[d] RCV phased in starting in year indicated (fully implemented in 2000 for Bolivia, 1978 for Federated States of Micronesia, 2003–2008 then 2014 for Morocco, 1981 in Bosnia and Herzegovina, 1992 in Malta).

[e] Nonmember state.

[f] Campaigns used to deliver vaccine during prior years.

[g] Introduction of two-dose schedule in the indicated year led to actual delivery of a second dose to children in 1973 for Croatia, 1999 for Denmark, 1993 for Norway, and 1994 for Sweden (i.e., second dose introduced at an earlier age in the schedule).

[h] MMR suspended due to mumps component of vaccine in 1993, which impacted delivery of rubella component.

[i] Dose at six months counted such that dose at nine months counted as a second dose.

Table II.

Assumptions for Supplemental Immunization Activities (SIAs) for Areas with Any Historical SIAs and Associated References Characterized by the Antigen(s) Used (i.e., M, R, or MR, the Latter Two Bolded for Visibility), the SIA Start Year [Number of SIAs Started that Year if Greater than 1], and as National (n) or Subnational (s)

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Africa (AFR)			30,31,33,302,303
Algeria	DZA	M:1996n, 2003n, 2007n, 2011s	
Angola	AGO	M: 1997s, 1999s, 2003n, 2006n, 2009n, 2011n, 2014n; **MR**: 2017n[a], 2020n[a]	
Benin	BEN	M: 1967s, 1997s, 1998s, 1999s, 2001s, 2003s, 2005n, 2008n, 2011n, 2014n; **MR**: 2017n[a], 2020n[a]	28
Botswana	BWA	M: 1997s, 1998s, 2001n, 2005n, 2009n, 2013n; **MR**: 2016n[a], 2019n[a]	35
Burkina Faso	BFA	M: 1967s, 1998s, 1999n, 2001n, 2004n, 2007n, 2009s, 2011s, 2012[2]s; **MR**: 2014n 2018n[a], 2020n[a]	28,304–306
Burundi	BDI	M: 1999s, 2001s, 2002s, 2003s, 2004n, 2005n, 2006n, 2009n, 2010[2]s, 2011s, 2012n; 2013n; **MR**: 2015n[a], 2019n[a]	
Cameroon	CMR	M: 1969s, 1999s, 2001[2]s, 2002n, 2006s, 2007s, 2009n, 2010[2]s, 2011s, 2012n; **MR**: 2015n[a], 2018n[a]	28,40–45,307,308
Cape Verde	CPV	M: 1998n, 2005n, 2009n; **MR**: 2013n, 2017n[a]	
Central African Republic	CAF	M: 1967s, 1998s, 2005s, 2006s, 2008n, 2011n, 2013[4]s; **MR**: 2017n[a], 2019n[a]	28,47,48
Chad	TCD	M: 1967s, 1997s, 1999s, 2005[2]s, 2006s, 2008n, 2009[3]s, 2011s, 2012n, 2014[2]n, 2016n[a]; **MR**: 2018n[a], 2020n[a]	28,49–51,309
Comoros	COM	M: 2003s, 2005s, 2006s, 2007n, 2010s, 2013n; **MR**: 2016n[a], 2019n[a]	
Congo, Democratic Republic	COD	M: 1996s, 1997s, 1999s, 2000s, 2002s, 2003s, 2004s, 2005s, 2006[2]s, 2007n, 2008s, 2009s, 2010s, 2011[5]s, 2012[15]s, 2013[3]s, 2014[5]s; **MR**: 2016n[a], 2019n[a]	58
Congo, Republic	COG	M: 1967s, 1998n, 2004[2]s, 2007n, 2010n, 2011[2]s, 2012n, 2013n, 2015n[a], 2016n[a]; **MR**: 2017n[a], 2018n[a], 2019n[a], 2020n[a]	28,54,56,57
Cote d'Ivoire	CIV	M: 1967s, 2003[2]s, 2005n, 2008n, 2011n, 2014n; **MR**: 2017n[a], 2020n[a]	28
Equatorial Guinea	GNQ	M: 2003[2]s, 2005n, 2009n, 2011n, 2012n; **MR**: 2016n[a], 2018n[a], 2020n[a]	
Eritrea	ERI	M: 1997s, 1998s, 1999s, 2000[2]s, 2001s, 2003n, 2004s, 2006s, 2009n, 2012s; **MR**: 2015n[a], 2019n[a]	
Ethiopia	ETH	M: 1998s, 1999s, 2000[2]s, 2001s, 2002s, 2003[2]s, 2004s, 2005[2]s, 2006s, 2007s, 2008s, 2009[4]s, 2010[2]s, 2011[2]s, 2013n; **MR**: 2016n[a], 2019n[a]	59,60,63,64
Gabon	GAB	M: 1967s, 2004n, 2007n, 2012n, 2013[2]s; **MR**: 2016n[a], 2018n[a], 2020n[a]	28
Gambia, The	GMB	M: 1966s, 1967s, 1968s, 2003n, 2007n, 2011n; **MR**: 2015n[a], 2019n[a]	28,65–71
Ghana	GHA	M: 1967s, 2001s, 2002s, 2006n, 2010n; **MR**: 2013n, 2017n[a]	28,72–74,310
Guinea	GIN	M: 1967s, 2002s, 2003s, 2006n, 2009n, 2012n, 2015n[a]; **MR**: 2018n[a]	28

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Guinea-Bissau	GNB	M: 1999s, 2003s, 2006n, 2009n, 2012n, 2015n[a]; **MR**: 2018n[a]	75–77
Kenya	KEN	M: 1994s, 1999s, 2000s, 2002n, 2004s, 2005s, 2006[2]s, 2009n, 2012n; **MR**: 2015n[a], 2018n[a]	78–85
Lesotho	LSO	M: 1999s, 2000n, 2003n, 2007n, 2010n, 2013n; **MR**: 2016n[a], 2019n[a]	
Liberia	LBR	M: 1967s, 2004s, 2007n, 2008s, 2010n, 2011n; **MR**: 2017n[a], 2020n[a]	28,86
Madagascar	MDG	M: 1998[2]s, 2004n, 2007n, 2010n, 2013n; **MR**: 2016n[a], 2019n[a]	87
Malawi	MWI	M: 1998n, 1999s, 2002n, 2005n, 2008n, 2010n, 2013n; **MR**: 2016n[a], 2019n[a]	35,88,89
Mali	MLI	M: 1967s, 1998s, 1999s, 2001n, 2004n, 2007n, 2011n, 2012[2]s; **MR**: 2017n[a], 2020n[a]	28,90
Mauritania	MRT	M: 1967s, 1995n, 1997n, 1998[2]s, 1999n, 2000n, 2004n, 2008s, 2011[2]s, 2012s, 2014n; **MR**: 2017n[a], 2020n[a]	28,91
Mauritius	MUS	M: 1998s; **MR**: 2003s	
Mozambique	MOZ	M: 1997s, 1998s, 1999s, 2003[2]s, 2005n, 2008n, 2011n, 2013n; **MR**: 2016n[a], 2019n[a]	88,92–99
Namibia	NAM	M: 1997[2]s, 1998n, 2000n, 2003n, 2006s, 2009n, 2012n; **MR**: 2015n[a], 2018n[a]	100
Niger	NER	M: 1967s, 1997s, 1998s, 1999s, 2004s, 2005s, 2008n, 2010s, 2012n, 2015n[a]; **MR**: 2018n[a]	28,101,102
Nigeria	NGA	M: 1967s, 1999s, 2005s, 2006s, 2007[2]s, 2008n, 2011n, 2013[3]s, 2014s, 2015n[a]; **MR**: 2017n[a], 2019n[a]	28,103–110,311
Rwanda	RWA	M: 1999s, 2003n, 2006n, 2009n; **MR**: 2013n, 2017n[a]	111
Sao Tome and Principe	STP	M: 1999n, 2007n, 2012n; **MR**: 2015n, 2018n[a]	
Senegal	SEN	M: 1967s, 2003n, 2006n, 2010[2]n; **MR**: 2013n[a], 2017n[a]	28,112,312
Sierra Leone	SLE	M: 1967s, 2003n, 2006n, 2009n, 2012n; **MR**: 2015n[a], 2019n[a]	28,113
South Africa	ZAF	M: 1996[2]s, 1997[2]s, 2000s, 2004n, 2005s, 2007n, 2009[3]s, 2010n, 2013n; **MR**: 2016n[a], 2019n[a]	100,114
South Sudan	SSD	M: 1998s, 1999s, 2003s, 2004[4]s, 2005[3]s, 2006[2]s, 2007[2]s, 2008[3]s, 2010[2]s, 2011[2]n, 2012n, 2014n, 2014s, 2016n[a]; **MR**: 2018n[a]	
Swaziland	SWZ	M: 1998n, 1999n, 2002n, 2006n, 2009n, 2010n, 2013n; **MR**: 2016n[a], 2019n[a]	
Togo	TGO	M: 1967s, 2001n, 2004n, 2008n, 2010n, 2013n; **MR**: 2016n[a], 2019n[a]	28
Uganda	UGA	M: 1997s, 1998[2]s, 1999s, 2000[2]s, 2001s, 2003n, 2005s, 2006n, 2009n, 2012n, 2015n[a]; **MR**: 2018n[a]	
United Republic of Tanzania	TZA	M: 1999[2]s, 2000s, 2001s, 2002s, 2005n, 2006n, 2008s, 2011n; **MR**: 2014n, 2018n[a]	115
Zambia	ZMB	M: 1999s, 2002s, 2003s, 2007n, 2010n, 2012n 2015n[a]; **MR**: 2018n[a], 2019n[a]	
Zimbabwe	ZWE	M: 1997s, 1998n, 2002n, 2003s, 2006n, 2009n, 2010n, 2012n; **MR**: 2015n[a], 2018n[a]	
Americas (AMR)			116–119

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Argentina	ARG	M: 1993n, 1998n; **MR**: 2002n, 2005n, 2006n, 2008n, 2009n 2014n	120,121
Bahamas, The	BHS	M: 1991n; **MR**: 1997[2]s, 2003n, 2006n, 2007n	
Barbados	BRB	M: 1991n, 1996n; **MR**: 2004n, 2007n	122
Belize	BLZ	M: 1991n, 1993n, 1995n; **MR**: 2000n, 2004n, 2008n, 2010n	
Bolivia	BOL	M: 1994n, 1998n, 1999s, 2000s, 2002s; **MR**: 2003n, 2004[2]s, 2005s, 2006n, 2007s; 2015n[a]	123
Brazil	BRA	M: 1992n, 1995n, 1997[2]s, 1998s, 2000n; **R**: 2000s; **MR**: 2001s, 2002s, 2004n, 2008n, 2011n, 2014n	124–126
Canada	CAN	M: 1996n	127
Chile	CHL	M: 1992n, 1996n, 1999n, 2001n; **MR**: 2005n, 2007n	128–130
Colombia	COL	M: 1993n, 1995n, 2002n, 2003s; **MR**: 2005s, 2006[2]s, 2010n, 2011s	131
Costa Rica	CRI	M: 1967n; **MR**: 1993n, 1998n, 1999s, 2001n, 2002n	132–134
Cuba	CUB	M: 1993[2]s, 2002n; **R**: 1982n; **MR**: 1986n, 2007n	135,136
Dominican Republic	DOM	M: 1993n, 1998n, 1999[2]s, 2001n, 2003n; **MR**: 2004[2]n, 2006n, 2010n	137,139
Ecuador	ECU	M: 1994n, 1998n, 2002n; **MR**: 2003n, 2004n, 2008n, 2009n, 2011n, 2012n	138
El Salvador	SLV	M: 1993n, 1996n, 1997s, 2001n, **MR**: 2004n, 2005n, 2006n, 2007n, 2008n, 2012[2]s	138
Grenada	GRD	M: 1991n, 1996n, 2001n	
Guatemala	GTM	M: 1972–1979[b]n, 1993n, 1996n; **MR**: 2002n, 2003n, 2007n, 2008n, 2013n	139
Guyana	GUY	M: 1991n, 1996n, 2003n; **MR**: 2000n, 2007n	140–142
Haiti	HTI	M: 1994n, 1999n, 2010s; **MR**: 2001n, 2002n, 2003n, 2004n, 2006n, 2007s, 2008s, 2012n, 2013[3]s, 2015n[a], 2018n[a]	142
Honduras	HND	M: 1993n, 1996n, 2000n; **MR**: 2002n, 2003n, 2004n, 2008n, 2012[2]s	143
Jamaica	JAM	M: 1991n; **MR**: 1995n, 2000n, 2003s, 2004n, 2005n, 2006n, 2007n	144,145
Mexico	MEX	M: 1993n, 1998n; **MR**: 2002[2]s, 2004n, 2005n, 2006[3]s, 2008[2]s, 2010n, 2011n, 2012n, 2013n	146,147
Nicaragua	NIC	M: 1993n, 1996n, 1998n; **MR**: 2000n, 2002n, 2003n, 2004n, 2005[2]s, 2006n, 2008n, 2011n, 2012n	
Panama	PAN	M: 1993n, 1996n, 2000n; **MR**: 2003n, 2006n, 2008n, 2010[2]s	148,149
Paraguay	PRY	M: 1995n, 1998n; **MR**: 2003n, 2005n, 2009[2]s, 2013s, 2014n	147
Peru	PER	M: 1992n, 1995n, 1997n, 2001n; **MR**: 2003[2]s, 2004n, 2006n, 2011n	
St. Lucia	LCA	M: 1991n, 1996n	150
St. Vincent and the Grenadines	VCT	M: 1991n, 1995n	
Suriname	SUR	M: 1991n, 1997n; **MR**: 2005n, 2007n, 2010n	
Trinidad and Tobago	TTO	M: 1991n, 1997n	151,152
United States	USA	**R**:1970n	

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Puerto Rico[c]			
Uruguay	URY	M: 1994n, 1998[3]s; **MR**: 2003n, 2008n	
Venezuela, RB	VEN	M: 1994n, 1998n; **MR**: 2001[2]s, 2002n, 2003[3]s, 2004s, 2005n, 2006n, 2007n, 2009[2]s, 2013n, 2014n	131,159,160
Eastern Mediterranean (EMR)			161–163
Afghanistan	AFG	M: 1994s, 1995[2]s, 1996n, 1999s, 2002n, 2003n, 2006[2]s, 2007s, 2009n, 2011[3]s, 2012[2]s, 2013n, 2014[2]s, 2015n[a]; **MR**: 2018n[a]	164
Bahrain	BHR	**MR**: 1998n, 1999n	165,166
Djibouti	DJI	M: 2002s, 2003s, 2004s, 2005n, 2007s, 2008n, 2011n, 2012[2]s; **MR**: 2015n[a], 2019n[a]	
Egypt, Arab Rep.	EGY	M: 1998s, 2000s, 2002n; **MR**: 2008s, 2009s	167,168
Iran, Islamic Rep.	IRN	M: 1996s, 1999s; **MR**: 2003n, 2007[2]s, 2010s, 2012s	169,170
Iraq	IRQ	1995n, 2002n, 2009[5]s, 2010[2]s, 2011s, 2012s, 2013; **MR**: 2004[3]s, 2005[2]s, 2006s, 2007n, 2008[5]s	171
Jordan	JOR	M: 1997n, 1999n, 2003s; **MR**: 2004s, 2005n, 2012s, 2013[2]s	172
Kuwait	KWT	M: 1994n; **MR**: 1998n, 2010s	173
Lebanon	LBN	M: 1978n, 1990n, 1994n; **MR**: 2000n, 2008s, 2013s	
Libya	LBY	**MR**: 2005n, 2008[2]s, 2009[2]s	
Morocco	MAR	**MR**: 2008[2]s, 2013n, 2016n[a]	174
Oman	OMN	**MR**: 1994n	175–177
Pakistan	PAK	M: 2005s, 2007[4]s, 2008s, 2010[3]s, 2011[5]s, 2012n, 2013[2]s, 2014[3]s; **MR**: 2017n[a], 2020n[a]	
Qatar	QAT	**MR**: 2000n, 2005n, 2007n	
Saudi Arabia	SAU	**MR**: 1998n, 2000s, 2004n, 2007n, 2011[2]n	178
Somalia	SOM	M: 2002s, 2005s, 2006s, 2007s, 2008[2]s, 2009[3]s, 2010n, 2011[8]s, 2012[3]s, 2013s, 2014s; **MR**: 2016n[a], 2018n[a], 2020n[a]	179
Sudan	SDN	M: 1998s, 1999s, 2003s, 2004[4]s, 2005[3]s, 2006[2]s, 2007[2]s, 2008[3]s, 2010[2]s, 2011[5]s, 2012s, 2013s; **MR**: 2016n[a], 2019n[a]	
Syrian Arab Republic	SYR	M: 2003s, **MR**: 1998n, 2004s, 2005s, 2007[2]s, 2008n, 2009s, 2012n, 2013[2]s, 2014n	
Tunisia	TUN	M: 1998n, 2001n, 2002n; **MR**: 2005	180,181
United Arab Emirates	ARE	**MR**: 1998n, 1999n, 2001n	182
Yemen, Rep.	YEM	M: 2001s, 2004s, 2005s, 2006s, 2007s, 2009[2]s, 2010s, 2011s, 2012n, 2013s; **MR**: 2014n, 2017n[a], 2020n[a]	
Europe (EUR)			183–188,313,314
Albania	ALB	M: 1970–1989[b]n; **MR**: 2000n, 2002n, 2003	189
Armenia	ARM	M: 2008n; **MR**: 2007	190
Austria	AUT		

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Azerbaijan	AZE	M: 2004n; **MR**: 2006[2]s, 2014n	190
Belarus	BLR	M: 2012n; **R**: 2005s, 2006n	190,194
Belgium	BEL		
Bosnia and Herzegovina	BIH		
Bulgaria	BGR	**MR**: 2009n, 2010s	198
Croatia	HRV		
Cyprus	CYP		
Czech Republic	CZE		
Denmark	DNK	**MR**: 2012n	202
Estonia	EST		
Finland	FIN		
France	FRA		
Georgia	GEO	M: 2004s; **MR**: M: 2004[4]s, 2005n, 2008[2]s, 2013n	209
Germany	DEU		
Greece	GRC		
Hungary	HUN	M: 1969n, 1970n, 1971n, 1973[2] n, 1974[2]n	216
Iceland	ISL		
Ireland	IRL	**MR**: 2009n	218,219
Israel	ISR		
Italy	ITA	**MR**: 2007s	222,223
Kazakhstan	KAZ	**MR**: 2005n	190,224
Kyrgyz Republic	KGZ	**MR**: 2001n, 2002s	190,225,226
Latvia	LVA		
Lithuania	LTU		
Luxembourg	LUX		
Macedonia, FYR	MKD	**MR**: 2009n	196,229
Malta	MLT		
Moldova	MDA	**MR**: 2002[2]s	190
Montenegro	MNE		
Netherlands	NLD		
Norway	NOR		

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Poland	POL		
Portugal	PRT		
Romania	ROU	M: 1979–1989[d]n; **MR**: 1998n, 2010n, 2011[2]s	236,237
Russian Federation	RUS	M: 2004s, 2005n, 2008n, 2010s	190
Serbia	SRB	**MR**: 2003s, 2004[2]s, 2005s	238
Slovak Republic	SVK	M: 2002n; **MR**: 2003s	201
Slovenia	SVN		
Spain	ESP		
Sweden	SWE		
Switzerland	CHE		
Tajikistan	TJK	M: 2004n; **MR**: 2009n	190
Turkey	TUR	M: 1985n, 2003[2]s, 2004s, 2005s	249–251
Turkmenistan	TKM	**MR**: 2007n	190
Ukraine	UKR	**MR**: 2008n	190,252
United Kingdom	GBR	M: 1994n; **MR**:1994n, 2004s	253–256
Uzbekistan	UZB	**MR**: 2006s, 2007s, 2011n	257,258
Southeast Asia (SEAR)			SEAR
Bangladesh	BGD	M: 1995s, 1998s, 1999s, 2001s, 2005s, 2006s, 2010n; **MR**: 2014n, 2018n[a]	259
Bhutan	BTN	M: 1995n, 1996s, 2000s; **MR**: 2006n	260
India	IND	M: 1995s, 1996s, 1997s, 1999s, 2000s, 2001s, 2010s, 2011[2]s, 2012[2]s, 2013n	261,262
Indonesia	IDN	M: 1997s, 2000[2]s, 2002[2]s, 2003s, 2004s, 2005[2]s, 2006[3]s, 2007[4]s, 2008s, 2009[3]s, 2010s, 2011s; **MR**: 2016n[a], 2017n[a], 2018n[a]	263
Korea, Dem. Rep.	PRK	M: 1995s, 1999n, 2007n	
Maldives	MDV	M: 1995n, 1996n, 1997s; **MR**: 2005n, 2006n, 2007n	
Myanmar	MMR	M: 1995s, 1996s, 1997[2]s 2002s, 2003s, 2004s, 2007n, 2012n; **MR**: 2015n[a]	264
Nepal	NPL	M: 1995n, 2004n, 2005[2]s, 2008[3]s; **MR**: 2012[3]s, 2015n[a], 2018n[a]	
Sri Lanka	LKA	M: 2003s, 2013s; **MR**: 2004n	265
Thailand	THA		
Timor-Leste	TLS	M: 2003n, 2006n, 2009n, 2011n; **MR**: 2015n[a], 2020n[a]	
Western Pacific (WPR)			270,271

Region and Member State	ISO	SIA Antigen Used: Year[Number Started that Year if Greater than 1] and Scope (n or s)	Refs.[21]
Australia	AUS	M: 1998n	272,273
Brunei Darussalam	BRN		
Cambodia	KHM	M: 2000n, 2001[2]s, 2002n, 2003n, 2004n, 2005n, 2007n, 2011[2]s; **MR**: 2013n, 2017n[a]	
China	CHN	M: 2003s, 2004s, 2005[4]s, 2006s, 2007s, 2008[2]s, 2009[2]s, 2010n; **MR**: 1998s, 1999s	274–276
Hong Kong SAR, China[c]	HKG	M: 1997s; **MR**: 2002n	315
Macao SAR, China[c]	MAC	**MR**: 20011n	
Fiji	FJI	M: 1997n, 2001n; **MR**: 2006n, 2011	280,281
Japan	JPN		
Korea, Rep.	KOR	M: 2001n, 2004n, 2005n; **MR**: 2006n, 2007n, 2008n, 2009n	285,286
Lao PDR	LAO	M: 1998s, 2000s, 2001s, 2007n; **MR**: 2011s, 2012s, 2014n, 2017n[a], 2020n[a]	287,288
Malaysia	MYS	M: 2004n, 2005n; **R**: 1989n; **MR**: 2012[3]n, 2012[3]s	289–293
Micronesia, Fed. Sts.	FSM	**MR**: 2004s, 2010s: 2011s, 2013s, 2014[3]s	294
Mongolia	MNG	M: 1994n, 1996n, 2000n, 2001s, 2007n; **R**: 2009s; **MR**: 2012n	
New Zealand	NZL	**MR**: 1997n, 1998n	295,296
Papua New Guinea	PNG	M: 1997n, 2003s, 2004s, 2005s, 2009s, 2010n, 2012n; **MR**: 2015n[a], 2018n[a]	297–299
Philippines	PHL	M: 1998n, 2002s, 2004n, 2007n, 2009s, 2010s, 2013[2]s, 2014s; **MR**: 2011n, 2014n[a], 2018n[a]	
Samoa	WSM	M: 1998n, 2001n; **MR**: 2003n, 2008n, 2009n	
Singapore	SGP		
Solomon Islands	SLB	M: 1997n, 1998n, 2001n, 2006n, 2009n; **MR**: 2012n, 2014, 2018n[a]	
Tonga	TON	M: 1998n, 2001n	
Vanuatu	VUT	M: 1998n, 2001n, 2006n, 2009n; **MR**: 2013n, 2014n	
Vietnam	VNM	M: 1993n, 1994[2]s, 1995[2]s, 1996[2]s, 1997[2]s, 1998[2]s, 1999s, 2001s, 2002s, 2003s, 2004s, 2005s, 2007s, 2008s, 2010n, 2013s; **MR**: 2014[2]n	

[a] Assumption about future SIAs.

[b] Annually for all of the years listed (between and including the years listed).

[c] WHO nonmember.

[d] Two times per year for all of the years listed (between and including the years listed), SIAs for years 1994–1998 included booster dose given to school-age children during one of the two SIAs.